The institutional conditions of inequality in credential and skill attainment and their impact on occupational placement

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Keywords

educational credentials; worker skills; occupational status; labor market placement; credentialization; economic coordination; vocational education and training; wage bargaining; varieties of capitalism; inequality in educational outcomes; social stratification

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Research Ethics

This study uses secondary analysis of anonymized individual data collected by the OECD Survey of Adult Skills (PIAAC). As outlined in the PIAAC Technical Standards and Guidelines Section 2 on Ethics Standards, all survey participants gave their informed consent prior to their participation in the research and national survey institutes had to take adequate steps to protect participants' confidentiality (http://www.oecd.org/site/piaac/PIAAC-NPM%282014_06%29PIAAC_Technical_Standards_and_Guidelines.pdf).

Abstract

This study comparatively analyses inequalities in educational outcomes as well as education effects on the occupational status of prime-age workers across 21 countries. Considering two distinct aspects of educational outcomes—credentials and measured worker skills—the study's main role is to assess their partial effects on occupational placement, contingent on social origin. Overall, parental education effects on educational achievement in terms of both credentials and skills are large. Likewise, occupational status is strongly associated with educational certificate attained. Labor market placement based on worker skills is significant as well, but to a lesser extent. The individual-level path dependencies of origin-education and education-destination vary considerably across countries. In part, this variation is associated with a country's skills formation system in terms of vocational specialization and the degree of economic coordination as measured by bargaining coordination. In line with prior research, vocational specificity relates to increased educational inequality. In addition, the study finds that economic coordination mitigates educational inequality as it reduces the intergenerational transmission of certificates and skills. In systems in which vocational specificity is accompanied by a high degree of coordination, the detrimental inequality effect of vocational specificity tends to level off. Moreover, economic coordination facilitates occupational placement based on worker skills. A concise discussion of the policy implications concludes this paper.

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1 Introduction

Education plays an important role in mediating social origin and socio-economic outcomes, as has been well documented in the extensive literature on status attainment and intergenerational social mobility. Strong associations between origin and education on the one hand, and between education and occupational destination on the other, have been reported. The direct effect of education on occupational placement is much larger than that of social origin (e.g. Sewell, Haller & Ohlendorf, 1970). A basic distinction in educational outcomes can be made between formal educational attainment levels, i.e. the credentials obtained, and the skills actually possessed by individuals or populations. This study analyzes origin-education (OE) and education-destination (ED) associations across countries by differentiating credentials and worker skills. It examines whether measured worker skills, in addition to educational certificates, can aid our understanding of social inequalities in educational achievement and occupational attainment. In addition to separating educational credentials from occupational-relevant skills (measured as adult proficiency in numeracy and literacy) the assessment of contextual and moderating effects of country-level variables is a key contribution. In this respect, not only effects of educational institutions on the OE and ED associations are analyzed, but also the impacts of country variation in economic coordination. Previous literature has covered this aspect much less than that of educational institutions.

As well as information on the highest level of education attained, the Survey of Adult Skills (henceforth PIAAC[1]) conducted by the Organization for Economic Co-operation and Development (OECD, 2013a) provides direct and comparable measures of key cognitive skills, and thus makes it possible to comparatively study the associations of both types of

[1] The acronym PIAAC stands for *Programme for the International Assessment of Adult Competencies*.

educational outcomes. Drawing on this data, this study describes how countries vary in the two-way associations between (1) social origin and education, and (2) education and destination, when education is subdivided into credentials and worker skills. First, comparative results on the inequalities in educational outcomes in terms of educational groups and measured skills (OE association), as well as their effects on labor market outcomes (ED association), are presented for 21 countries. Based on the assumption that country differences in educational institutions and in economic coordination influence the formation of educational outcomes contingent on social origin as well as the allocation of social position and economic rewards, the estimated cross-country differences are then explained by countries' institutional features.

The remainder of the paper is as follows. Section 2 outlines theoretical perspectives on credentials and skills, and describes how these concepts relate to existing research on social inequality in education attainment and the effect of education outcomes on occupational placement. This is followed by a discussion of the institutional country effects and how they are expected to moderate the partial effects of credentials and skills. The data and technical details are introduced in section 3, section 4 presents the results, and section 5 summarizes and concludes.

2 Credentials and worker skills in comparative perspective

2.1 Differences and commonalities between educational credentials and worker skills

Educational credentials pertain to formal learning, which usually takes place in an institutionalized education system. Typically, a credential (i.e. certificate or degree) is awarded upon successful completion of a formal education program to certify that a specific set of skills associated with the program has been achieved. Education thus makes an important contribution to the formation of productive capacities as it transforms cognitive and non-cognitive native abilities into skills that are more or less useful in the labor market.

In studies of the labor market outcomes of education, it is common for the skill endowments of individuals to serve as proxies for formal qualifications attained. Indeed, the rationale behind this approach is that credentials and skills are correlated. However, credentials and skills are not interchangeable because they relate to different concepts that cover certain aspects of educational achievement. Consequently, it has been shown that there is substantial skills heterogeneity among individuals who have attained a credential at the same educational level, or even the same credential (Green & McIntosh, 2007; Kerckhoff, Raudenbush & Glennie, 2001). Independently and net of each other, both skills and credentials are determinants of labor market success. Over and above formal education attained, measured worker skills are positively related to wages (Van de Werfhorst, 2011). While cognitive skills account for a considerable share of the total education effect in terms of earnings, their relative importance varies systematically across countries according to the organization of their schooling system (Barone & Van de Werfhorst, 2011).

Indeed, as can be seen in Figure 1, the data used in this study looks at heterogeneous skills as well. Within educational groups the dispersion between the 5th and 95th percentiles amounts to more than 3 standard deviations, while the interquartile range is larger than 1.2 standard deviations in each group.[2] When comparing the median proficiency scores or certain percentiles of the distributions across the four educational categories, a skills hierarchy is evident. Individuals who attained higher levels of formal education tend to outperform those who attained lower levels. Moreover, a horizontal differentiation of the middling educational level between vocational- and general-oriented programs with similar quantities of cumulative years of schooling shows the expected result that general programs tend to outperform vocational ones. Nevertheless, and this is the point I wish to make here, the distributions of adjacent groups largely overlap, and even between the highest and the lowest educational group there is substantial overlap. Accordingly, almost 25% of individuals in the lowest group

[2] In literacy, 1 standard deviation amounts to 43 proficiency points in the lowest, and 37 points in the highest, educational group. In numeracy, the dispersion is larger and amounts to 47 and 41 points, respectively.

who have attained no more than lower secondary education (ISCED 0-2) and up to 50% of those with upper secondary education (ISCED 3-4) perform better than 25% of tertiary-educated individuals. This holds true for both numeracy and literacy proficiency, which show very similar distributions.

Insert Figure 1 about here

Direct measures of cognitive skills provided by survey data normally correspond to broadly transferable skills that do not represent the full spectrum of knowledge, skills, and competences associated with an education certificate. Nor do they reflect the specific, technical, skill sets necessary to fully perform the tasks of certain occupations. In addition, the skill sets valued in the labor market consist of specific vocational and professional skills along with other generic skills such as interaction, communication, learning abilities, and physical skills. Different occupational segments demand different skill sets in which the relevance of generic skill measures varies. However, cognitive numeracy and literacy skills constitute a foundation for the development of specific technical and professional skills and thus determine job performance (see Abrassart, 2013). Pedagogical research on vocational education suggests that generic skills are highly correlated with the development of domain-specific practical skills, and that the former serve as a proxy for prospective, professional skill development.[3] Moreover, literacy and numeracy are, together with work ethic, considered important employability skills (see Rosenberg et al., 2012). Liu and Grusky (2013) report that US labor markets increasingly reward cognitive analytical skills, for whose development the skill measures provided by PIAAC are essential, while they find that technical and creative skills are valued less.

The concepts of numeracy and literacy skills are implemented in PIAAC as "'key information-processing skills' that are relevant to adults in many social contexts and work

[3] Examples from Germany and Switzerland, e.g. for the vocational domains business and engineering, can be found in Winther and Prenzel (2014).

situations, and necessary for fully integrating and participating in the labour market" (OECD, 2016a, p. 20). They are generic, analytical, problem-solving skills that are demanded by the labor market because they are needed to respond appropriately to a variety of workplace tasks and work contexts (OECD, 2013c). For example, numeracy is defined "as the ability to access, use, interpret and communicate mathematical information and ideas," with the aim of "managing a situation or solving a problem in a real context, by responding to mathematical content/information/ideas represented in multiple ways." (OECD, 2016b, p. 18).

Given that credentials and skills refer to different concepts of educational achievement that vary empirically, it is of interest—within the limitations of skill and qualification measures provided by observational data—to assess their net effects on occupational placement across countries and to analyze whether there are differential social origin effects on the formation of these two types of educational achievement. Rather than substitute for indirect measures of human capital like formal qualifications, it is held that direct skill measures complement them. Combining both concepts can offer greater insight into the processes of skills acquisition and their occupational outcomes, at both individual and country level.

2.2 The formation of credentials and skills and their occupational outcomes

Formal education has become an important institution that mediates family background and occupational outcomes. In line with the lesson learned from status attainment research building on the seminal work of Blau and Duncan (1967), it is fair to assume that on average across countries the direct family effect on offsprings' occupational status is small compared with the indirect family effect mediated by educational achievement variables. Substantial parental education effects on credential and skill achievement should therefore correspond to considerable effects of credentials and skills on occupational status attainment.

2.2.1 OE linkage

The abundant sociological research on educational stratification has elaborated in great detail on inequality of educational attainment associated with socio-economic background characteristics in comparative perspective (e.g. Breen & Jonsson, 2005; Breen, Luijkx, Müller & Pollak, 2009; Shavit & Blossfeld, 1993). Social origin, most often measured by parental education or occupational status, can affect educational attainment through various channels. Education systems value certain types of cognitive abilities, attitudes, and values that are prevalent and reinforced predominantly among the higher social classes and higher educated backgrounds. Parents' interest in their children's development is likely to motivate and create a supportive environment in order to facilitate academic success. In addition to the social and cultural advantages of doing this, higher levels of economic resources allow members of wealthier households to take riskier educational choices and go onto higher levels of education, even in cases where performance at school is no better than that of working class students who decide not to transit to the next educational level and instead leave formal education.

There is no reason to expect that social reproduction in educational outcomes differs systematically between credentials and skills. Both outcomes may benefit from advantageous backgrounds in similar ways. Indeed, family effects on educational outcomes are well-established in terms of both credentials and skills; in the case of social inequality in skill attainment in schools, this has been highlighted by the large-scale, international assessments of student performance conducted by the International Association for the Evaluation of Educational Achievement (IEA) and the OECD (e.g. PISA, TIMSS, PIRLS). However, the analytical reports produced from this data show marked country variation in student performance differences related to socio-economic background (e.g. OECD, 2013d), suggesting that national education systems influence educational inequalities considerably. Consequently, school systems differ widely in the extent to which they succeed in providing

beneficial opportunities for all against the backdrop of diverse student populations, and mitigating unequal background characteristics.

2.2.2 ED linkage

Sociological and economic accounts of the ED association draw on various theoretical approaches that differ with respect to the micro-level explanations they offer for the observed education-job link (see Bills, 2003). Human capital theory (HCT) (Becker, 1964) posits that the skills accumulated in education and on the job make a significant difference to workers' labor market outcomes. Schooling is understood as a mechanism of merit-based selection, given free educational and occupational choice. The basic mechanism underlying the ED link is that individuals' productive capacities, which are determined by the skills learned during periods of education and training, are rewarded by the labor market accordingly. For the rest, neoclassical assumptions apply, i.e. within perfectly competitive markets, fully-informed and rational individuals maximize utility and employers' profits.

In the process of matching workers to jobs, however, firms do not know the true productive capacities of job seekers. Instead, they screen job applicants for signals that allow them to assess their potential productivity. Important signals on which both sides of the market rely in the hiring process are educational certificates. As employers screen the labor market, job seekers acquire education to signal that they are able to meet the skill demanded by employers. However, contrary to HCT, signaling and screening theorists (Arrow, 1973; Spence, 1973) do not believe that education *per se* enhances productivity. Rather, the skills required to perform job tasks well are acquired through on-the-job-training after entering the labor market. To save on training costs, employers prefer to hire those with high levels of education as this is expected to correlate positively with unobserved characteristics that will facilitate efficient on-the-job-training, like ability, work ethic, motivation, and readiness to learn. In line with HCT assumptions, abler individuals acquire higher levels of education

because the costs and the risks associated with the educational investment are lower for them than for less able individuals.

The credentialist view (Collins, 1979), on the other hand, breaks with this conceptualization and holds that it is not the superior skills of the better educated but their ability to exclusively access higher job ranks, thus benefitting from a mechanism of social closure. Although schooling and productivity are not independent in this view, the returns to educational credentials are higher than the gains in productivity associated with their attainment. This reasoning fits well with the above-mentioned observation that workers holding the same credential differ with respect to their skills and productive capacities, as do workers who occupy the same job, a situation that has been termed "heterogeneous skills" (Green & McIntosh, 2007). Credentialist theory allows for a conceptualization of the impact of institutional structures on job assignment that goes beyond technological or organizational factors in the workplace to those of the education system itself and to the system of industrial relations.

So, what can be understood from the micro-level approaches to the two different concepts of education put forward in this study? In competing for jobs, job seekers may want to invest more in education in order to signal high potential productivity. If this leads to a situation in which less able individuals attain the same educational levels as more able individuals, this could be one reason for the observed skills heterogeneity within educational groups. As more and more individuals attain higher levels of education, credentials may forfeit their signaling capacity, and thus direct measures of skills may play an increasing role in labor market transactions (through checks, assessments, personal interviews, and the like). It is, however, possible that the most productive workers are at the same time more successful in accessing higher status jobs, potentially because they can benefit from their skills in the hiring process, e.g. due to better information. In such situations, the explanations put forward by either theory are not unconnected as they are more or less relevant for both types of educational

achievement.[4] The relative effects of credentials and skills on occupational placement can be differentiated with regard to their timing as well. Workers have earned their educational credentials, which are very important in the labor market entrance phase, years or even decades ago, whereas surveys that assess worker skills at the same time as occupational information is collected reflect the "skills for which the labor market is *currently* rewarding workers" (Kerckhoff et al., 2001, p. 3).

Previous attempts to evaluate the explanatory power of skills compared with educational attainment in labor market outcomes have been made for single countries, predominantly the United States (see Kerckhoff, et al., 2001). While the basic finding of earlier studies was that worker skills do not contribute much to the explanation of labor market outcomes once credentials are controlled for, Kerckhoff et al. found differential effects across ethnic groups. The few comparative studies available so far suggest that relative effects vary across countries (Barone & Van de Werfhorst, 2011; Bol & Weeden, 2015; Van de Werfhorst, 2011). These studies point to an association between the relative value of educational certificates and worker skills, and the degree of credentialization in occupational placement (see section 2.3 below).

To sum up, the following hypotheses are tested against the data with regard to the micro-level mechanisms of OE and ED linkages:

H1: Parental education effects on credentials correlate positively with their effects on worker skills across countries, as social reproduction is similar for both educational dimensions.

H2: In contrast, the relative effects of credentials and skills on occupational placement are negatively associated across countries, because if the partial effect of worker skills on occupational placement is high, the partial effect of certificates is expected to be low and vice versa.

[4] I thank an anonymous reviewer who made me aware of this situation.

2.3 The institutional context

The institutional literature on education and skill formation systems focuses on the dimensions of stratification and vocational specificity (Allmendinger, 1989; Bol & Van de Werfhorst, 2013; Breen, 2005; Kerckhoff, 1995; Wolbers, 2003). Differences in these variables at the system level were found to have distinct implications for the status and quality of occupations attained, including promotion patterns, further training opportunities, and wages. Stratified systems track students at relatively early stages into distinct educational paths, providing them with various vocational specializations largely within initial education. Educational tracking in combination with vocational education and training has been found to strengthen the impact of family background on educational achievement (e.g. Pfeffer, 2008) and subsequent occupational outcomes, which leads to less educational mobility (for a review see Bartlett, 2009).

With respect to differences in student performance, Hanushek and Wößmann (2006) found that comprehensive school systems reduce inequality in educational outcomes while stratified systems increase it. Likewise, OECD (2013b) shows a negative correlation between horizontal educational stratification and equity in education, meaning that students' socio-economic origin has a stronger effect on their performance in systems that track students at early ages into different educational pathways and in which vocational programs are prevalent at the upper secondary level, compared with comprehensive and less vocational-specific systems. Across OECD countries, early selection, the number of different tracks, and the prevalence of vocational programs are strongly correlated. However, according to Brunello and Checchi (2007), there are two counteracting effects of vocational education on the impact of parental background: while the "diversion effect" keeps lower-class students away from higher education, the "specialization effect" on the other hand countervails the parental effect because vocational education enhances the labor market prospects of the disadvantaged, eases the transition from school to work, and promotes further training and the development of adult

skills beyond initial schooling. It remains unclear though, whether the two effects balance each other out or whether one dominates the other.

According to the Varieties of Capitalism (VoC) approach's influential argument of institutional complementarity, skill formation systems have evolved in correspondence with production regimes, labor market institutions, and industrial relations systems (Hall & Gingerich, 2009; Hall & Soskice, 2001). In particular, the prevalent mode of economic coordination and the level of social protection are closely related to the vocational specificity of secondary schooling systems (Estevez-Abe, Iversen & Soskice, 2001). In the presence of generous social protection and coordination the risks of investing in vocation-specific skills are reduced since employment protection is high, wage bargaining beyond the firm level ensures that skills are rewarded and, where there is unemployment, benefits mitigate income losses. Following on from Busemeyer and Jensen (2012), who argue that economic coordination matters most in explaining educational investments and returns of *workers* while social protection pertains to the socio-economic situation of *the unemployed*, this study focuses on countries' levels of economic coordination. Bargaining coordination is seen as a key variable in the VoC literature because it indicates the degree to which employer behavior is influenced by non-market factors such as deliberative institutions and collective actors at various levels. Moreover, collective wage bargaining is assumed to influence the impact of vocational specificity on inequality.

Busemeyer and Iversen (2012) found that less labor market stratification occurs only in systems in which vocational specificity is complemented by high levels of coordination. In liberal market economies where bargaining coordination is low, employers rely primarily on competitive market mechanisms to coordinate industrial relations and exchanges with other economic spheres. In such less regulated systems, wage bargaining mainly takes place at the company level. In highly regulated, coordinated market economies, on the other hand, collective wage bargaining takes place at the industry-level or may even encompass the whole

economy. In these economies, the argument goes, it is efficient for employers to contribute to long-term investment strategies in high-quality production, including skill investments that aim to develop a highly skilled and specialized workforce with transferable vocational skills. Likewise, workers have incentives to invest in vocational-specific skills because their investment is likely to be rewarded by any firm in the industry or sector. As a result, skill endowments of workers without academic credentials are expected to be higher in coordinated economies than in systems with low levels of coordination. It is thus assumed that inequality in skill achievement among all workers decrease with the degree of coordination.[5] Inequality in the attainment of educational credentials is expected to decrease with coordination as well, because liberal systems with rather fragmented market coordination have developed relatively large higher education sectors. This leads to particularly high proportions of tertiary-educated individuals, while leaving those outside higher education with rather low levels of secondary education.

Educational credentials are relevant labor market entry signals. But especially in coordinated and highly regulated labor markets they will continue to be critical determinants of occupational status throughout an individual's working life, as in such credentialized systems, educational certificates are door-openers to legally regulated professions (Di Stasio et al., 2016). In less regulated systems, in which labor market transactions are guided by the market mechanism to a greater extent, the human capital explanation should be of higher relevance in explaining occupational outcomes. As employers become more and more aware of the true productive capacities their employees possess, they may use this information—within the constraints imposed on their economic activities—in their decisions about layoffs, promotions, and related training opportunities. Regulated labor markets, on the other hand,

[5] The VoC approach refers to different vocational-specific skills than the skill measures used in this study. However, as mentioned before, the two are closely related since generic skills are foundations for technical skills.

constrain employers' decisions to a greater extent and allow them less discretion to adapt to productivity changes or the availability of better matches (Sørensen, 1983).

Previous attempts have been made to relate the observed country variation in the relative labor market value of credentials and skills to institutional characteristics. In his analysis of the effects of the institutional characteristics of schooling systems in 18 countries, Van de Werfhorst (2011) found significant differences across countries and the credential explanation more relevant in strongly vocational-oriented schooling systems, while skills added little to the explanation of the education-job link in terms of earnings in these systems. The argument is that credentials in occupation-specific education systems convey more reliable information on the skills associated with their attainment, and thus employers have better signals about candidates' typical productive capacities than they would from more comprehensive systems that are less vocationally specific. Likewise, Barone and Van de Werfhorst (2011) found country variation in labor market returns to different forms of cognitive skills which could be explained by differences in the education systems and labor market regulations, in particular with regard to the level of credentialization in access to occupations. As professionalization and occupational regulation are prevalent in countries with a high level of economic coordination and vocational specificity, access to a wide range of occupations legally requires certain credentials or licenses. Thus the credentialist view is expected to be more relevant in strongly regulated education and occupational systems in which entitlements are connected to educational credentials obtained through formal education, than in less regulated systems in which the human capital explanation should be of higher relevance.[6] To sum up, the following

[6] Of course, credentialization is not a characteristic exclusively displayed by coordinated market economies, as it is to some extent present in liberal market economies as well. In fact much of the work on further elaborating closure as a social phenomenon was done in the United States. For example, Weeden and Grusky (2014) recently showed that by restricting the supply of credentials and licenses, closure creates occupational and educational rents that account for the extreme income inequality in the higher levels of the U.S. income distribution. Even in liberal systems, real markets, and in particular labor markets, are never perfectly competitive. The concept of open and closed social relationships and its association with credentialization was originally developed by Weber (1980) when he described the rise of the "Bildungspatente" required to enter public service within the German bureaucracy (pp. 551-580).

hypotheses regarding the institutional determinants of individual-level relationships will be tested:

H3: In countries where education systems sort students into different educational programs later, inequality in credential and skill attainment is lower.

H4a: Vocational-specific education systems are associated with higher inequalities in credential and skill attainment.

H4b: In vocational-specific systems labor market credentialization is expected to be more relevant in explaining the education-job linkage, i.e. credentials are more relevant than worker skills for occupational status attainment.

H5a: Higher levels of economic coordination are associated with lower levels of educational inequality across countries.

H5b: Economic coordination is associated with higher levels of labor market credentialization.

3 Data and variables

The sample consisted of prime-age workers (30- to 49-year olds) in 21 countries who took part in the first round of the PIAAC survey conducted in 2011/12. In each country, at least 5,000 individuals aged 16 to 65 were interviewed and underwent a skills assessment. The survey is designed to provide cross-culturally and cross-nationally valid data on education, individual skills, and occupation, together with a wide range of background information including parental education and social origin. The data thus offers the opportunity of analyzing skill-formation systems and their outcomes from a comparative perspective. The countries included were: Austria, Belgium (Flanders), Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany, (the Republic of) Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Slovak Republic, Spain, Sweden, the United Kingdom

(England and Northern Ireland only), and the United States. Workers below the age of 30 were excluded from the analysis to ensure that most people had completed their initial education. The upper age limit of 49 was set to avoid potential bias from country variations in pension systems and early retirement. Country-level data was obtained from several sources (see below).

3.1 Individual-level variables

The occupational status variable was categorized according to International Socio-economic Index of Occupational Status (ISEI) scores (Ganzeboom et al., 2010), which were assigned to participants' current occupation or, in case of the unemployed, the last job they had held in the five years prior to the survey. PIAAC provides job information according to the 2008 International Standard Classification of Occupations (ISCO-08) at the 2-digit level (sub-major groups). For Canada, Estonia, and Finland, only information for the major groups at the 1-digit level was available.

Educational outcomes were separated into educational credentials and worker skills. Credentials were rated in terms of the highest level of formal education completed. PIAAC provides this information according to the International Standard Classification of Education 1997 (ISCED 97). The classification used here aggregates the data into three main vertical levels (low, medium, and high) and one horizontal dimension that differentiates the medium level into general- and vocational-oriented programs, resulting in four categories: (1) lower secondary education or less (ISCED02, including ISCED 3C short), (2) upper secondary or post-secondary education with vocational orientation (ISCED34V), (3) upper secondary or post-secondary education with general orientation (ISCED34G), and (4) tertiary education (ISCED5A6, degree level). The focus when analyzing country variation in educational stratification was on the latter category, which was also termed the higher education (HE) credential. Further differentiation at this degree level was not feasible because only very few

doctoral degrees were observed (fewer than ten in half of the countries) and observations of bachelor degrees were very low in some countries where the Bologna degree structure had been implemented recently (i.e. Austria, Belgium, Czech Republic, Slovak Republic).[7]

Worker skills in numeracy and literacy were measured using a cognitive assessment. Survey respondents were asked to complete tasks of varying difficulty with regard to (1) the content of the tasks (i.e. artefacts, tools, knowledge, representations, and cognitive challenges), (2) the processes (i.e. the cognitive strategies required to respond to or use the content appropriately), and (3) the context in which the tasks occurred (e.g. work-related, personal, society and community, or education and training). Numeracy tasks included the calculation of change, use of spreadsheets, application of formulae, handling of money and budgets, or the interpretation of quantitative information and statistical messages. The resulting skill was rated on a continuum of proficiency, with scores below 226 points belonging to the lowest skill level 1, and scores equal to or higher than 376 points belonging to the highest skill level 5. Individuals at the intermediary numeracy level 3 (276 to less than 326 points) were able to apply number sense and spatial sense, recognize and work with mathematical relationships, patterns, and proportions expressed in verbal or numerical form, and interpret data and statistics in texts, tables and graphs (see OECD, 2016b).

By design the resulting skill proficiency scores are comparable across countries, the actions taken to develop cognitive tasks free of cultural and national bias being state-of-the-art in large-scale assessment methodology. Each respondent was given ten plausible values (PVs)

[7] Harmonizing country-specific education variables into cross-national measures like the ISECD is a complex task and it has been shown that inconsistent implementation practices across countries may limit comparability (see Schneider, 2010). Despite the best efforts of the OECD and national survey agencies to obtain comparable education measures, one cannot rule out measurement issues. This has to be kept in mind when interpreting the results. Moreover, a more detailed educational categorization than the one employed here would have been preferable. This was not feasible, however, because sample size constraints combined with cross-national differences concerning which specific ISCED categories to apply would have resulted in empty cells in the country-education table. However, at the medium level, a horizontal differentiation of distinct national programs which have been collapsed into one ISCED category was feasible. Information on program orientation is provided by a separate variable that draws on the original national education categories and expert information, as reported by national PIAAC coordinators.

assigned to each domain (numeracy and literacy). The PVs were imputed from *a posteriori* distribution using a latent regression model that scaled the results of the cognitive assessment, and supplemented by demographic characteristics from the background questionnaire (OECD, 2013c). In this study, the imputation variance is accounted for by the estimation procedure used (see Appendix B). The skill measures were a compound of cognitive ability and a multitude of learning outcomes over the life course, reflecting not only formal education achievements but also informal learning in the workplace and in everyday life. The credential measure may also have captured education-related merits and non-cognitive or professional skills that are not represented by numeracy or literacy proficiency. This should be borne in mind when interpreting the results. Another problem that limits the interpretation of the skill effects on occupational attainment is that of reverse causality, because worker skills and occupational information refer to the same point in time. Consequently, causation between the two variables cannot be established and thus associations will be reported and discussed.

Parental education was rated according to three categories using the ISCED 97 classification: (1) neither parent has upper secondary education, (2) at least one parent has upper secondary education, and (3) at least one parent has obtained a tertiary degree.[8] The following individual-level controls were used: age, dummy variables for female, foreign-born parents (indicating if both parents were born in a foreign country), and employment status (indicating if respondents were unemployed at the time of the survey). The sample was restricted to subjects who were in dependent employment at the time of the survey or who were unemployed but had been employed in the five years before the survey. Occupation information was therefore available for either the current or last period of employment. Furthermore, only individuals who had earned their educational credential in the country of their current residence were selected, since only those credentials could be related to domestic

[8] Reducing social origin to parental education was inevitable because no information on parental occupation was available. This is certainly a limitation, since only one aspect of the multi-dimensional nature of social origin can be analyzed.

education institutions. This applied to 33,460 subjects, of whom 31,667 cases had complete data. However, since not all variables were included in all models, the sample size changes accordingly (see sample statistics in Table A1 in Appendix A). The data has been weighted by sampling weights to account for selection probabilities.

3.2 Country-level variables

The following country-level variables were analyzed with respect to their direct effects on individual-level outcomes (credentials, skills, and occupational status) and their moderating effects on individual-level path coefficients:

1. Differentiation in education systems, as measured by age at which students were selected into different educational programs for the first time (age of first selection).
2. Vocational specificity, as measured by the proportion of students in upper secondary education who were in vocational tracks with combined school- and workplace-based learning (i.e. within a dual system). This indicates the extent to which the education system provides strong signals about the professional skill endowments of certificate holders. This measure is preferred over the proportion of upper secondary students in vocational tracks (including those in full-time vocational schools) because it reflects the extent to which close links between education and the world of work exist (Breen, 2005). Both education system indicators were calculated from their average 2007 to 2012, as reported in respective volumes of *Education at a Glance* by the OECD (2009-2014).
3. Bargaining coordination data,[9] drawn from the ICTWSS (Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts) database in 34 countries

[9] The scale distinguishes five levels of coordination: 5 = economy-wide bargaining, based on a) enforceable agreements between the central organizations of unions and employers affecting the economy or entire private sector, or b) government imposition of a wage schedule, freeze or ceiling; 4 = mixed industry and economy-wide bargaining, where a) central organizations negotiate non-enforceable central agreements (guidelines) and/or b) key union and employers' associations set the pattern for the entire economy; 3 = industry bargaining with no or irregular pattern setting, limited involvement of central organizations and limited freedoms for company bargaining; 2 = mixed industry- and firm-level bargaining, with weak enforceability of industry agreements; 1 = none of the above, only fragmented bargaining mostly at company level.

between 1960 and 2012 (see Visser, 2013). The data refers to the average for the years 1997 to 2006.

4. Overall level of investment in education (as measured by expenditure on education as a percentage of GDP, OECD) was mainly used to control for differences in the degree of importance countries attached to education, which also reflects country variation in demand for credentials and skills. Country variation in supply was controlled for by including mean values for the individual-level explanatory variables of parental education, credential, numeracy, and literacy. These variables controlled for country differences in relative skill investments as well as average educational endowments of prime-age workers and their parents.

To relate recent institutional characteristics to skill formation and the labor market processes of 30- to 49-year olds may constrain interpretation of the findings. However, historical developments in education and industrial relations systems are path-dependent and thus stable over time. Accordingly, the economic coordination measure used here shows high stability since the early 1990s and only some variation before that. Likewise, the vocational specificity measure has been very stable since the mid-1990s when the OECD first published comparative data on participation in combined school- and workplace-based education (Education at a Glance, 1998, reference year 1996), and there has been only one change in the age of first selection since 2003 (OECD, 2005).[10]

4 Results

The hypotheses were tested by fitting various models to the data. Separate country models were used to analyze the micro-level mechanisms of credentials and worker skills formation and their effects on occupational placement. Contextual and moderating effects of the country-level institutional variables were then analyzed by two-level random coefficient

[10] Poland is misclassified in the first publication

models. Alternative model specifications were applied to the data and to subsets of the data to assess the robustness of the results.

4.1 Comparative results of micro-level OE and ED linkages

The results of the separate country models confirm Hypothesis 1. In all countries the attainment of both higher education credentials and worker skills is strongly influenced by parental education. As expected, substantial country variation in social origin effects exists. The left panel of Figure 2 reveals a specific pattern, in the sense that if the parental effect on the credential is low or high its effect on the skill measure tends to be low or high as well. This positive relationship is expressed by a strong correlation between country parental effects on the two education outcomes (Pearson r=0.78). In general, relatively low parental effects on both dimensions are observed in the Nordic countries Finland, Sweden, Denmark, and Norway. This is in line with the conventional wisdom that education systems in these countries provide educational opportunities relatively independent of social origin. The former soviet central European countries the Czech Republic, Slovak Republic, and Poland, now part of the Visegrád group, cluster on the other end of the distribution along with the United States, Germany, and Italy. In these countries, parental education affects both educational achievement variables more than in most other countries in the sample.

Although the correlation is strong and the graph shows good linear approximation, some notable peculiarities can be observed. There is a group of countries with similar middling parental effects on credential attainment that differ with respect to numeracy skill transmission. Among them are the liberal countries United Kingdom (England and Northern Ireland) and the Republic of Ireland with above average numeracy skill transmission, and Canada, which seems to have higher levels of social mobility in this regard. These three liberal systems differ from the US, with its high parental effects, on both educational outcomes. Another remarkable case is Germany, which differs greatly from the other

continental European coordinated market economies of the Netherlands, Austria, and Belgium. The latter cases display similar low levels of skill transmission (like Finland and Denmark), although the attainment of a HE degree depends more on social origin in BE than in NL, with AT in the middle. Korea and Japan are located, together with Spain, in the lower left quadrant of relatively high social mobility in educational attainment, while France and Estonia are close to the average on both dimensions. As with the Nordic countries, social inequalities in skill achievement are also relatively low in the far-east countries Korea and Japan. Although credentials tend to be awarded contingent on social origin in Japan, its education system seems to do well in equipping workers, including those from low-educated backgrounds, with high skill levels. The weak influence of students' socio-economic background on learning outcomes in Japan is explained by the fact that financial and personnel resources are distributed equitably among schools and students (OECD, 2012). Disadvantaged students not only have equal access to qualified teachers, i.e. no difference in teacher quality is observed for advantaged students as is the case in other countries, but also enjoy extra support and financial subsidies. The same applies to the Korean education system, in which both the quantity and quality of human resources are distributed equitably (OECD, 2014).

(Figure 2 about here)

In the right panel of Figure 2, the effects of HE credentials on occupational status attainment are plotted against the numeracy effects estimated for each country separately. Across the 21 countries the two effects are negatively correlated (r=-0.55), which means that in countries where the average partial credential effect on labor outcome is high, the partial numeracy effect (and literacy as well, see Table A3) tends to be low, and *vice versa*. This is in line with hypothesis 2, which summarizes the theoretical assumption that in some countries the credential explanation of the education-job link is more relevant than in others, where the human capital explanation of productive skills seems to be of higher relevance in occupational

placement. Net of each other, both educational outcome variables are significant determinants of status attainment. Despite country variation in the coefficients and their negative relationship, the HE credential effect exceeds the standardized skill effect in all countries in the sample.[11]

While this suggests that on average across the 21 systems labor markets are substantially characterized by credentialization of the education-job link, the human capital mechanism of merit-based allocation of social status is also present. Net of the credential attained, skills have relatively large effects on labor market outcome in the liberal economies of the United Kingdom (standardized coefficient 0.28), Republic of Ireland (0.24), Canada (0.21), and the US (0.20). In Austria (0.26) and the Nordic countries Norway (0.27) and Sweden (0.23), skills seem to be as relevant to occupational status attainment as they are in the liberal countries. Overall, country variation in the skill effect is rather small. However, the merit-based explanation seems to have the lowest relevance in the three Visegrád states in our sample and Italy, where the standardized skill effect ranges from 0.07 (Slovak Republic) to 0.12 (Czech Republic), followed by Spain (0.13), Japan (0.14), Finland (0.15), and Korea (0.16). While in the liberal systems of Canada and the United Kingdom the credential effect is—in line with theoretical assumptions—relatively low, the United States and Ireland have average levels of credentialization with respect to HE degrees. Labor markets seem to be most credentialized in the Slovak Republic, Germany, and Italy, followed by the other two Visegrád countries Poland and the Czech Republic. Above-average labor market credentialization is observed in Finland and Austria as well. In Germany and Austria where credentialization is high, presumably due to their professional occupation systems, skills are estimated to have above-average effects on occupational placement as well. Japan and Korea, on the other hand, have relatively low educational effects on both dimensions, suggesting that the association between

[11] The skill variables have been standardized by dividing by 2 standard deviations to facilitate direct comparison with untransformed binary predictors, in this case the HE credential (see Gelman, 2008).

occupational status and education in terms of educational credentials *and* skills is weaker there than in other countries.

4.2 Moderating contextual effects of countries' institutional characteristics

To assess the extent to which the institutional country-level variables moderate the path dependencies of the OE and ED linkages (hypotheses H3 to H5), the individual-level coefficients are allowed to vary across countries and regress on the country-level predictors within a two-level modelling framework. These cross-level interactions are separately estimated by six random slopes models which can be formally written as:

$$y_i \sim N(\beta_{0j} + \beta_{1jk} S_{ik}, \sigma_y^2), \text{ for i = 1,…, n and k = 1,…, K random slopes,}$$

where β_{0j} is the random intercept, β_{1jk} is the random slope parameter of slope S_{ik}, and σ_y is the standard deviation estimated from the data. The dependent variable y_i is either the HE credential (random slope k = 1), numeracy (k = 2), literacy (k = 3), or the occupational outcome (k = 4-6). In the country-level model, the random intercepts and random slopes are assigned a probability distribution with variation in the random coefficients with means, standard deviations, and a between-group correlation parameter ρ estimated from the data

$$\begin{pmatrix} \beta_{0j} \\ \beta_{1j} \end{pmatrix} \sim N\left(\begin{pmatrix} \gamma_{00} + U_j \gamma_0 \\ \gamma_{10} + U_j \gamma_1 \end{pmatrix}, \begin{pmatrix} \sigma^2_{\beta_0} & \rho\sigma_{\beta_0}\sigma_{\beta_1} \\ \rho\sigma_{\beta_0}\sigma_{\beta_1} & \sigma^2_{\beta_1} \end{pmatrix} \right), \text{ for j = 1,…, J countries,}$$

where U_j is the vector of the country-level predictors, γ_0 the associated vector of direct effects (on the random intercepts), and γ_1 the vector of moderating effects of these predictors.[12] Table 1 shows the results of the moderating effects analysis.

[12] An alternative modelling approach is to regress the country-level estimates presented in section 4.1 on the country-level predictors. However, I prefer two-level random coefficient models for two reasons: first, separate country analysis may overstate the variability in the individual-level estimates across countries, e.g. because of differences in the sample sizes of the countries and unequal variation within and between countries; and second, multilevel modelling incorporates unequal uncertainty of country-level effects by breaking down the observed co-variance into a within- and between-country part. Moreover, the specification of random slopes allows for

Hypothesis 3 that expects increased educational inequality in systems which require educational decisions at younger ages does not hold in the specification used here. As can be seen in Table 1, country variation in the parental education effects on both HE credential and worker skill attainment seem to be independent of the age of first selection. This result is at odds with part of the literature, although the evidence available is mixed (Breen and Jonsson, 2005). A potential explanation may be that in comprehensive school systems various forms of streaming within schools or classes (e.g. ability grouping) act as a functional equivalent to external tracking between different institutions and school types. Also, while tracking may increase inequality in skill attainment during initial education, this effect may diminish later in working life, potentially due to the specialization effect of vocational education, which, according to Brunello and Checchi (2007), may be generated by the curricula in vocational schools that seem to bolster further training and adult skills and thereby mitigate the impact of social origin. This corresponds to the finding that differentiated systems with substantial vocational sectors are conducive to adult numeracy attainment (OECD, 2013a). As regards the relationship between occupational status and either of the two educational outcome variables, educational stratification in terms of early tracking does not seem to make a difference in the education-job link either. While it is known that more comprehensive education systems relate to a higher proportion of HE credentials among the workforce, the analysis suggests that this does not moderate OE and ED linkages across the 21 countries.

Hypothesis 4a regarding vocational specificity is supported by the analysis in large part. Results are in line with existing evidence that finds vocational education reinforcing family background effects on education attainment (Bartlett, 2009; Hanushek & Wößmann, 2006). Vocational-specific systems are associated with higher educational inequalities in skill and credential attainment. Although in the main specification the moderating effect on HE credential attainment is significant at the 10% level only, the effect proves significant at the

estimating inter-individual variation in response to a country's social gradient (see Cleasby, Nakagawa & Schielzeth, 2015).

1% level when the variable on system stratification is omitted. Because there is a relatively strong negative correlation between the age of first selection and vocational specificity, all models are run for either of the two variables without the other (see section 4.3 and Table S2 in the online supplement).

Turning to occupational status attainment (models K4-K6 in Table 1), vocational specificity is positively associated with country variation in the labor market effects of both education dimensions. This finding is consistent with the theoretical expectation (hypothesis 4b) that credentialization is of particular relevance in vocational-specific education systems in which occupational entitlements are related to the credentials obtained from upper secondary education, through either apprenticeship training or other forms of VET programs that include workplace training. However, as measured worker skills tend to be of higher importance for job placement in vocational-specific systems as well, both dimensions of education are more relevant in explaining occupational attainment in such systems. On one hand, the diversion effect of vocational education contributes to labor market credentialization; at the same time, the specialization effect tends to some extent to mitigate credentialization and educational inequality in the sense that in vocational-specific systems numeracy and literacy skills are rewarded more in the labor market compared with less specific systems. Like Van de Werfhorst (2011), this study finds no clear relationship between education system differentiation and skill effects on labor market outcomes. However, while Van de Werfhorst finds that the skill effect on earnings is lower in vocational specific systems, the results presented here suggest that vocational specificity is associated with stronger skill effects on occupational placement across countries.

(Table 1 about here)

The analysis supports hypothesis 5a. Across the 21 countries analyzed, economic coordination in terms of bargaining is strongly associated with lower levels of social inequality in

educational attainment as measured by credentials and skills. This rather novel finding advances the view that the involvement of various actors at different levels contributes to equal educational opportunities in both credential and skill attainment. The negative residual correlation of the skill formation models (K2 and K3) suggests that countries with high levels of numeracy and literacy skills have lower social inequality in skill achievement than do countries with lower average skill levels. As a result, greater equity in skill achievement translates into the higher skill endowment of the workforce, which points to a desirable win-win situation.

Hypothesis 5b must be rejected. Contrary to the expectation of a higher degree of labor market credentialization in highly coordinated economies, bargaining coordination is associated with higher skill effects on occupational status, while no moderating role on the credential effect is observed. As a result, bargaining coordination tends to increase a merit-based allocation to social positions in the labor market. Hence in coordinated market economies skills are not only more equitably distributed among the workforce than in less regulated systems, but these skills seem to be more beneficial for job placement as well. The finding that economic coordination is functional both in terms of social cohesion and skill formation counters the argument that highly regulated industrial relations systems deprive skills from their impact on occupational placement. The result that bargaining coordination does not moderate the credential effect may result from country differences in the signaling capacity of credentials that may represent skills more accurately in highly regulated systems than in some countries with less coordination.

The human capital model is also more relevant in explaining labor market allocation in systems that spend a higher proportion of their wealth on education. This might result from higher levels of competitiveness and technological innovation, which increase labor markets' demand for productive skills, in addition to high levels of formal schooling.

4.3 Sensitivity analysis

To check the robustness of the presented results, several alternative model specifications have been applied to the data as well as to subsets of the sample. Because education system stratification (age of first selection) and vocational specificity are strongly negatively correlated (r=-0.60), the analyses were performed by including only one of the two variables at a time. The same was done for vocational specificity and coordination, because these two variables are positively related. At the country level, the following variables were included in the analysis to observe whether they would alter the results: average firm size (because of its potential relationship with skill formation processes and on-the-job training); and, the proportion of females in the workforce (to check for country variation in labor market composition according to gender). In a subsequent step, data for Canada, Estonia, and Finland was excluded, because occupational data is available only at the ISCO 1-digit level for these countries, to see if this had any impact on the results. Finally, the data was split into different age groups to test whether the influence of the country explanatory variables, which relate to recent years, changed across cohorts. The results are fairly robust to these alternative specifications.[13]

5. Summary and discussion

This study comparatively analyzed social inequality in educational attainment as well as education effects on occupational status attainment across 21 OECD countries. Considering two distinct aspects of educational outcomes—educational credentials and measured worker skills—the study attempted to assess their partial effects on occupational placement contingent on social origin in terms of parental education. Country variation in the individual-level path dependencies was then explained by modelling cross-level interactions with the vocational specificity of the countries' education system and level of economic coordination.

[13] The results of these models are available in an online supplement.

The main findings are as follows. Educational outcomes of prime-age workers in terms of both credentials and skills are strongly influenced by their parents' educational level. Comparative results show that parental education effects on both educational outcomes are strongly and positively related across countries. As expected, small parental background effects on the educational achievement variables are observed in the Nordic countries Finland, Sweden, and Denmark, but also in Korea and the Netherlands. The Czech Republic, Slovakia, and Poland, cluster at the opposite end of the spectrum, along with the United States, Germany, and Italy, in experiencing large parental background effects. In contrast to parental effects on the two educational outcomes, which are positively correlated, there is a negative relationship between the effects of the two educational dimensions on occupational status attainment: in countries where credentialization tends to be high the human capital explanation of productive skills is less relevant, and *vice versa*. The liberal countries of the United Kingdom (England and Northern Ireland) and Canada cluster on the merit-based side, with relatively large effects of the skill variables and relatively small credential effects, while the Visegrád countries in the sample and Italy are on the other side, with strong credential effects and relatively weak skill effects.

The main contribution of the study is the finding that country variations in the relationships observed are related to institutional variables. In countries with a high degree of economic coordination, the link between social origin and workers' own educational outcomes in terms of certificates and measured skills is weaker than in less coordinated countries. At the same time occupation placement in these systems is based more on merit in terms of measured worker skills than on the credential attained, which contributes to socio-economic mobility. Consequently, coordinated market economies tend to mitigate educational inequality while increasing the effectiveness of worker skills for occupational placement, compared to economies with a lower degree of coordination. Therefore, the involvement of various actors at different levels in the way labor market supply and demand relationships are coordinated

seems to be not only beneficial for a relatively equitable distribution of high skill levels among the workforce, but also for workers to have their skills rewarded accordingly in the labor market.

Countries with vocational-specific education systems show higher levels of inequality in skill attainment among their workforce. Regarding the ED linkage, vocational specificity is associated with higher education effects on status attainment in respect of both credentials and skills. As a result, a dominant system of combined school- and workplace-based training in initial education at the upper secondary level is associated with a greater tendency to social stratification. However, in systems in which vocational specificity is accompanied by a high degree of bargaining coordination, the detrimental effects level off. With respect to the moderating effect of countries' educational institutions on occupational opportunities, the study adds to earlier research by analyzing both credentials and skills in an origin-education and education-destination framework. In line with previous findings, this study found that the effects of worker skills vary across countries according to differences in their education systems. However, the current study found stronger associations between worker skills and occupational placement in vocational-specific systems, in addition to the prevalence of credentialization in such systems, compared to general systems. The finding that labor market credentialization is particularly high in countries with a large combined school- and workplace-based education and training sector corroborates the prior research results.

From a policy perspective, it might be of particular interest that both vocational specificity and bargaining coordination institutions are—independent and net of each other—positively related to the skill effects on occupational placement, while coordination tends to compensate for the unfortunate inequality impact of vocational specificity. Against the backdrop of the prominent role vocational education and training (VET) has for decades had on the European education reform agenda, what can be taken from these findings? With the aim of increasing labor market prospects and tackling youth unemployment, the idea of policy transfer for VET

and the dual apprenticeship system has been reinforced throughout the course of the financial and economic crisis, despite the fact that prior attempts have not been particularly successful. The results of this study support the view that replicating VET systems in other countries will be difficult because of its path-dependency on historically grown institutional structures. VET systems are embedded in formal and informal institutional structures that typically require the involvement of stakeholders, among them enterprises, schools, trade committees, social partners, teacher unions, public authorities, and advisory boards, at different levels. This study suggests that a relatively large vocational sector combined with a low level of coordination is associated with high inequalities in educational and social outcomes. In turn, labor markets in these systems are characterized by credentialization while workers' numeracy and literacy skills are weakly related to their occupational placement. Comprehensive coordination seems to be important for VET to respond to labor market needs and ensure that the skills and competencies supplied are demanded and valued by employers. While the foundations of a good match between skill supply and demand may be laid in the demand-responsive initial VET, high levels of coordination seem to be particularly useful for maintaining and developing productive skills beyond schooling through on-the-job learning and ongoing training. Moreover, economic coordination may be seen as a precondition that the observed positive specialization effect of VET in terms of numeracy skills can translate into higher occupational outcomes.

However, the comparative findings show that in all countries the education-job link is better explained by credential attained than by skills in numeracy and literacy. While the rather weak relationship between occupational status and generic skills is in line with prior research, it requires explanation; all the more so as the skill measures used reflect their current distribution among the workforce, whereas educational credentials pertain to formal schooling received in the past, in many cases decades ago. Of course, credentialization is present in any real-world economy but the numbers of regulated, i.e. credentialized, professions differ across

countries and sectors. In light of the heterogeneous skills among education attainment levels and jobs, however, the findings may point to a mismatch between skills supply and demand, and to the suggestion that learning outcomes beyond initial education are not adequately recognized in labor market allocation. The well-known objection, that the relevance of numeracy and literacy skills varies considerably across occupations, and the recognition that a credential may represent productive skills other than numeracy and literacy, does not render the comparative results non-significant as long as the skill demands of occupations are cross-nationally comparable. After all, generic skills are highly correlated with more specific professional skills and as such they may be of at least some relevance in any vocational field.

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Tables

Table 1: Contextual moderation effects of country level variables (estimates from two-level random slopes models)

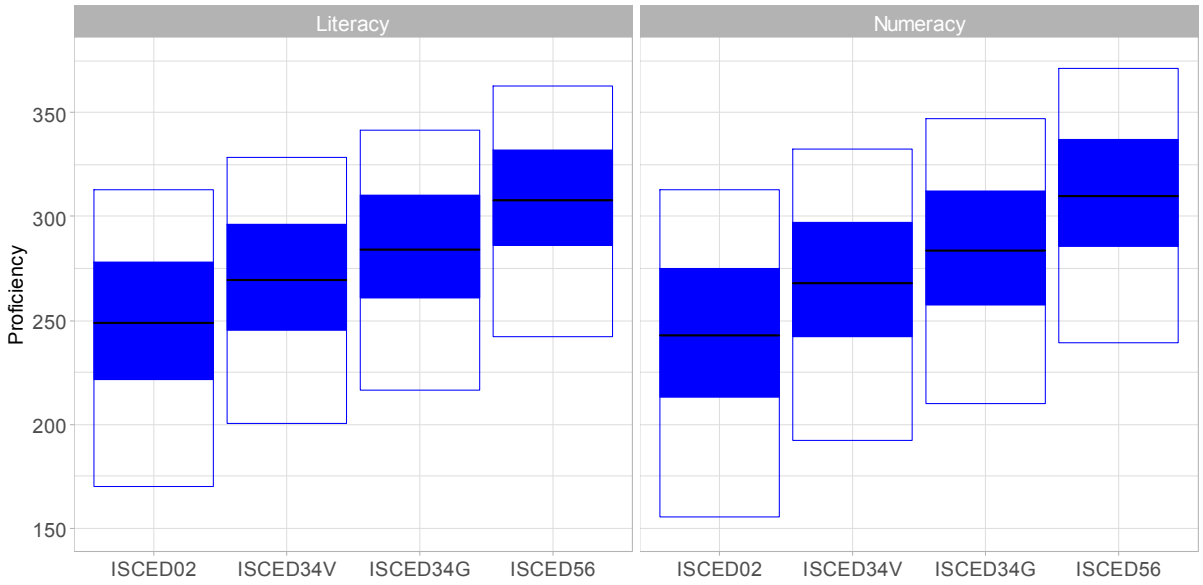
	K1: HE cred. ON PE	K2: Num. ON PE	K3: Lit. ON PE
Random slope ON			
Age of first selection	0.003 (0.056)	0.937 (0.705)	0.896 (0.706)
Vocational specificity	0.010° (0.006)	0.174* (0.081)	0.162* (0.082)
Bargaining coordination	-0.168** (0.049)	-2.858***(0.759)	-2.340** (0.797)
Expenditure on educ. (%GDP)	-0.110 (0.073)	-0.382 (1.409)	0.039 (1.637)
Mean IV: PE, HE, Num, Lit	-0.147** (0.055)	-0.061 (1.095)	-0.650 (1.200)
Intercepts			
Random slope	3.149***(0.564)	27.773***(7.392)	22.162** (7.817)
Dependent variable	3.834***(0.756)	274.968***(15.136)	283.310***(18.824)
Residual variance			
Random slope	0.045* (0.022)	11.405** (3.435)	12.565** (4.336)
Dependent variable	0.079* (0.033)	63.016***(16.222)	68.576***(15.825)
Residual correlation	-0.011 (0.023)	-18.189* (8.249)	-18.801** (6.139)
	K4: ISEI ON HE cred.	**K5: ISEI ON Num.**	**K6: ISEI ON Lit.**
Random slope ON			
Age of first selection	0.002 (0.406)	-0.023 (0.142)	-0.067 (0.134)
Vocational specificity	0.113** (0.042)	0.033* (0.015)	0.033* (0.015)
Bargaining coordination	-0.311 (0.485)	0.524***(0.136)	0.527** (0.170)
Expenditure on educ. (%GDP)	-1.322 (0.877)	0.721* (0.321)	0.860** (0.295)
Mean IV: PE, HE, Num, Lit	-0.116 (0.731)	-0.712***(0.147)	-0.699***(0.153)
Intercepts			
Random Slope	32.811***(5.604)	-0.653 (1.289)	-1.135 (1.423)
Dependent Variable	30.823***(6.430)	32.904***(4.412)	32.138***(4.337)
Residual variance			
Random slope	4.907* (2.020)	0.379* (0.172)	0.502** (0.188)
Dependent variable	5.582** (1.910)	4.085* (1.637)	4.105* (1.654)
Residual correlation	-2.376* (1.123)	1.194* (0.509)	1.136* (0.543)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.

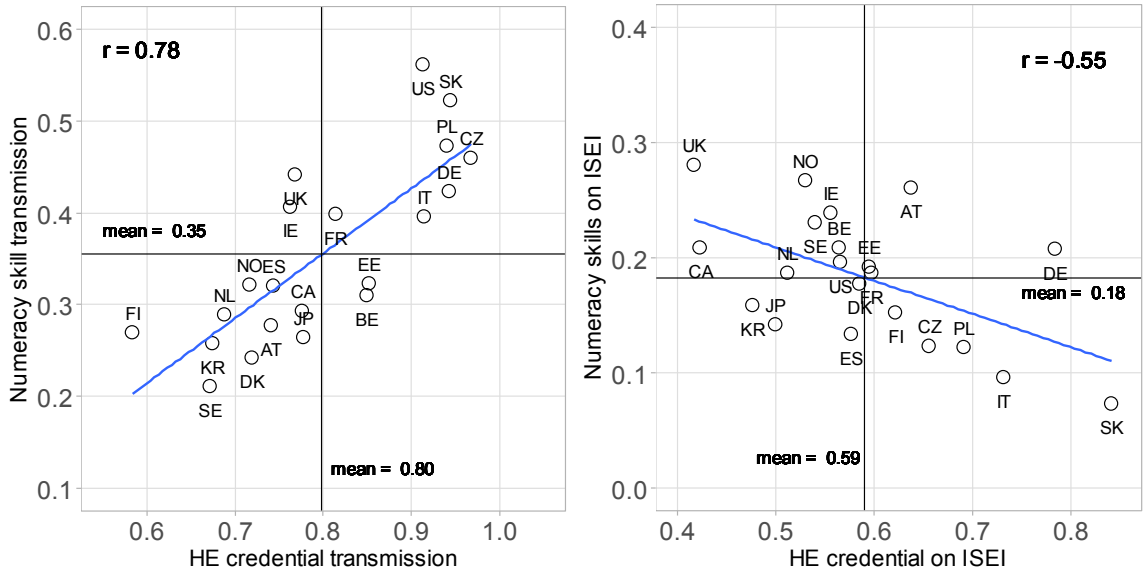
Figures

Figure 1: S kills heterogeneity in 21 OECD countries: distribution of numeracy and literacy proficiency scores across educational attainment groups



Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria; The figure shows the mean value (black line), the interquartile range (blue area), and the range between the 5th and the 95th percentile of the educational skill distributions. Educational groups are classified according to the International Standard Classification of Education 1997 (ISCED 97). ISCED02: primary education and lower secondary education (ISCED 0/1/2/3C short); ISCED34V: upper secondary and post-secondary education (ISCED 3ABC long/4), vocational orientation; ISCED34G: general orientation; ISCED56: tertiary education (ISCED 5AB/6).

Figure 2: Bivariate plots of country level estimates of parental effects on HE credential and numeracy attainment (left panel) and educational effects (HE credential and numeracy) on status attainment (right panel)



Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria; for estimates see Table A3 in Appendix A. Estimates are obtained from separate country models that take into account complex sampling structures and plausible values for numeracy. *HE credential transmission*: marginal predicted probability of attaining higher education (ISCED 56) for adults whose parents have attained higher education minus the probability for those whose parents have attained compulsory education only (ISCED 0-2). *Numeracy skill transmission*: coefficient of higher educated parents (vs. parents with compulsory education, y-standardized). *ISEI ON HE credential*: coefficient of higher education attainment (vs. compulsory education, y-standardized). *ISEI ON Numeracy skill*: coefficient of numeracy skill (standardized). All models control for age (ref.: 40 year olds), female (ref.: male), foreign born parents (ref: natives) and currently out of employment (ref.: employed).

Appendices

Appendix A: Sample statistics, country level data and country level estimates

Table A1: Sample statistics of individual and country level data

Variable	min	max	mean	SD	miss	n
Age	30	49	39.62	5.7	0	33,460
Female	0	1	0.45	0.5	0	33,460
Foreign-born parents	0	1	0.11	0.31	178	33,460
Currently jobless	0	1	0.12	0.32	0	33,460
Low parents educ. (ISCED02)	0	1	0.33	0.47	1,781	33,460
Medium parents educ. (ISCED34)	0	1	0.43	0.49	1,781	33,460
High parents educ. (ISCED56)	0	1	0.24	0.43	1,781	33,460
Low education (ISCED02)	0	1	0.12	0.33	0	33,460
Medium education, vocational (ISCED34V)	0	1	0.29	0.45	0	33,460
Medium education, general (ISCED34G, incl. ISCED5B)	0	1	0.35	0.48	0	33,460
High education (ISCED5A6)	0	1	0.23	0.42	0	33,460
pvnum1	38.84	450.09	277.21	49.5	0	33,460
pvnum2	50.18	464.01	277.07	49.47	0	33,460
pvnum3	27.75	462.2	277.07	49.46	0	33,460
pvnum4	14.11	446.62	277.36	49.37	0	33,460
pvnum5	29.93	450.41	277.40	49.45	0	33,460
pvnum6	21.63	450.27	277.51	49.68	0	33,460
pvnum7	36.83	446.95	277.30	49.47	0	33,460
pvnum8	17.99	463.85	277.36	49.76	0	33,460
pvnum9	20.96	450.79	277.35	49.49	0	33,460
pvnum10	28.46	460.5	277.52	49.48	0	33,460
pvlit1	30.76	432.56	279.11	44.80	0	33,460
pvlit2	62.47	443.36	279.22	44.77	0	33,460
pvlit3	16.23	431.3	279.31	44.71	0	33,460
pvlit4	0	435.54	279.38	44.79	0	33,460
pvlit5	9.63	433.05	279.19	44.60	0	33,460
pvlit6	57.51	435.52	279.19	44.85	0	33,460
pvlit7	2.77	427.97	279.17	44.72	0	33,460
pvlit8	0	459.25	279.03	44.77	0	33,460
pvlit9	43.28	436.39	279.13	44.79	0	33,460
pvlit10	0	437.79	279.12	44.72	0	33,460
Age of first selection	10	16	14.19	2.20	0	21
Vocational specificity	0	45.92	12.39	15.63	0	21
Bargaining coordination	1	5	2.98	1.34	0	21
Expenditure on educ. (%GDP)	4.37	7.94	6.06	0.97	0	21

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); pvnum/pvlit: plausible value in numeracy/literacy.

Table A2: Country level data

Country	Age of first selection	Vocational specificity	Bargaining Coordination	Education expenditure (%GDP)
AT	10	34.84	4.00	5.69
BE	12	2.98	5.00	6.58
CA	16	0.00	1.00	6.79
CZ	11	32.46	2.00	4.99
DE	10	43.43	3.60	5.13
DK	16	45.92	3.90	7.94
EE	15	0.33	1.60	5.53
ES	16	1.84	3.50	5.49
FI	16	12.61	4.80	6.47
FR	15	12.19	2.00	6.13
IE	15	2.71	4.00	6.15
IT	14	0.00	3.30	4.60
JP	15	0.00	4.10	5.14
KR	14	0.00	3.25	7.64
NL	12	19.88	3.60	6.22
NO	16	15.40	4.10	7.42
PL	16	6.43	1.00	5.46
SE	16	0.00	4.00	6.33
SK	11	29.08	1.80	4.37
UK	16	0.00	1.00	6.39
US	16	0.00	1.00	6.91

Source: Eurostat, OECD, Visser (2013).

Table A3: Country level estimates

	(1a) logit pared low	(1b) logit pared high	(1c) marg. prob. pared low	(1d) marg. prob. pared high	(1e) prob diff. (1d-1c)	**(1) HE cred. ON pared (1e/1d)**	**(2) Numeracy ON pared**	**(3) ISEI ON HE cred.**	**(4) ISEI ON numeracy**
AT	-2.68 (0.25)	-1.11 (0.11)	0.06	0.25	0.18	0.74	0.28 (0.06)	0.64 (0.05)	0.26 (0.03)
BE	-2.66 (0.20)	-0.27 (0.06)	0.07	0.43	0.37	0.85	0.31 (0.04)	0.56 (0.05)	0.21 (0.03)
CA	-2.49 (0.22)	-0.65 (0.07)	0.08	0.34	0.27	0.78	0.29 (0.03)	0.42 (0.05)	0.21 (0.03)
CZ	-4.19 (0.80)	-0.14 (0.93)	0.01	0.46	0.45	0.97	0.46 (0.09)	0.66 (0.09)	0.12 (0.04)
DK	-2.26 (0.20)	-0.68 (0.06)	0.09	0.34	0.24	0.72	0.24 (0.04)	0.59 (0.05)	0.18 (0.03)
EE	-2.90 (0.22)	-0.61 (0.07)	0.05	0.35	0.30	0.85	0.32 (0.04)	0.60 (0.04)	0.19 (0.03)
FI	-1.54 (0.12)	-0.30 (0.04)	0.18	0.43	0.25	0.58	0.27 (0.05)	0.62 (0.05)	0.15 (0.03)
FR	-2.18 (0.14)	0.20 (0.04)	0.10	0.55	0.45	0.81	0.40 (0.03)	0.60 (0.06)	0.19 (0.02)
DE	-3.76 (0.58)	-0.39 (0.49)	0.02	0.40	0.38	0.94	0.42 (0.06)	0.78 (0.06)	0.21 (0.03)
IE	-2.10 (0.13)	-0.15 (0.04)	0.11	0.46	0.35	0.76	0.41 (0.04)	0.56 (0.04)	0.24 (0.03)
IT	-2.87 (0.17)	0.53 (0.07)	0.05	0.63	0.58	0.91	0.40 (0.07)	0.73 (0.04)	0.10 (0.02)
JP	-1.91 (0.20)	0.33 (0.07)	0.13	0.58	0.45	0.78	0.26 (0.05)	0.50 (0.05)	0.14 (0.03)
KR	-1.47 (0.10)	0.30 (0.03)	0.19	0.58	0.39	0.67	0.26 (0.04)	0.48 (0.05)	0.16 (0.02)
NL	-1.45 (0.13)	0.46 (0.04)	0.19	0.61	0.42	0.69	0.29 (0.04)	0.51 (0.05)	0.19 (0.03)
NO	-1.84 (0.20)	-0.06 (0.06)	0.14	0.48	0.35	0.72	0.32 (0.05)	0.53 (0.04)	0.27 (0.03)
PL	-3.11 (0.35)	0.97 (0.20)	0.04	0.72	0.68	0.94	0.47 (0.06)	0.69 (0.06)	0.12 (0.03)
SK	-3.28 (0.32)	0.61 (0.18)	0.04	0.65	0.61	0.94	0.52 (0.06)	0.84 (0.05)	0.07 (0.03)
ES	-1.63 (0.11)	0.56 (0.03)	0.16	0.64	0.47	0.74	0.32 (0.04)	0.58 (0.04)	0.13 (0.03)
SE	-2.21 (0.18)	-0.85 (0.05)	0.10	0.30	0.20	0.67	0.21 (0.04)	0.54 (0.05)	0.23 (0.03)
UK	-1.87 (0.19)	0.30 (0.06)	0.13	0.57	0.44	0.77	0.44 (0.05)	0.42 (0.05)	0.28 (0.04)
US	-3.01 (0.37)	0.18 (0.20)	0.05	0.54	0.50	0.91	0.56 (0.06)	0.57 (0.07)	0.20 (0.05)
Mean			0.10	0.49	0.40	0.80	0.35	0.59	0.18

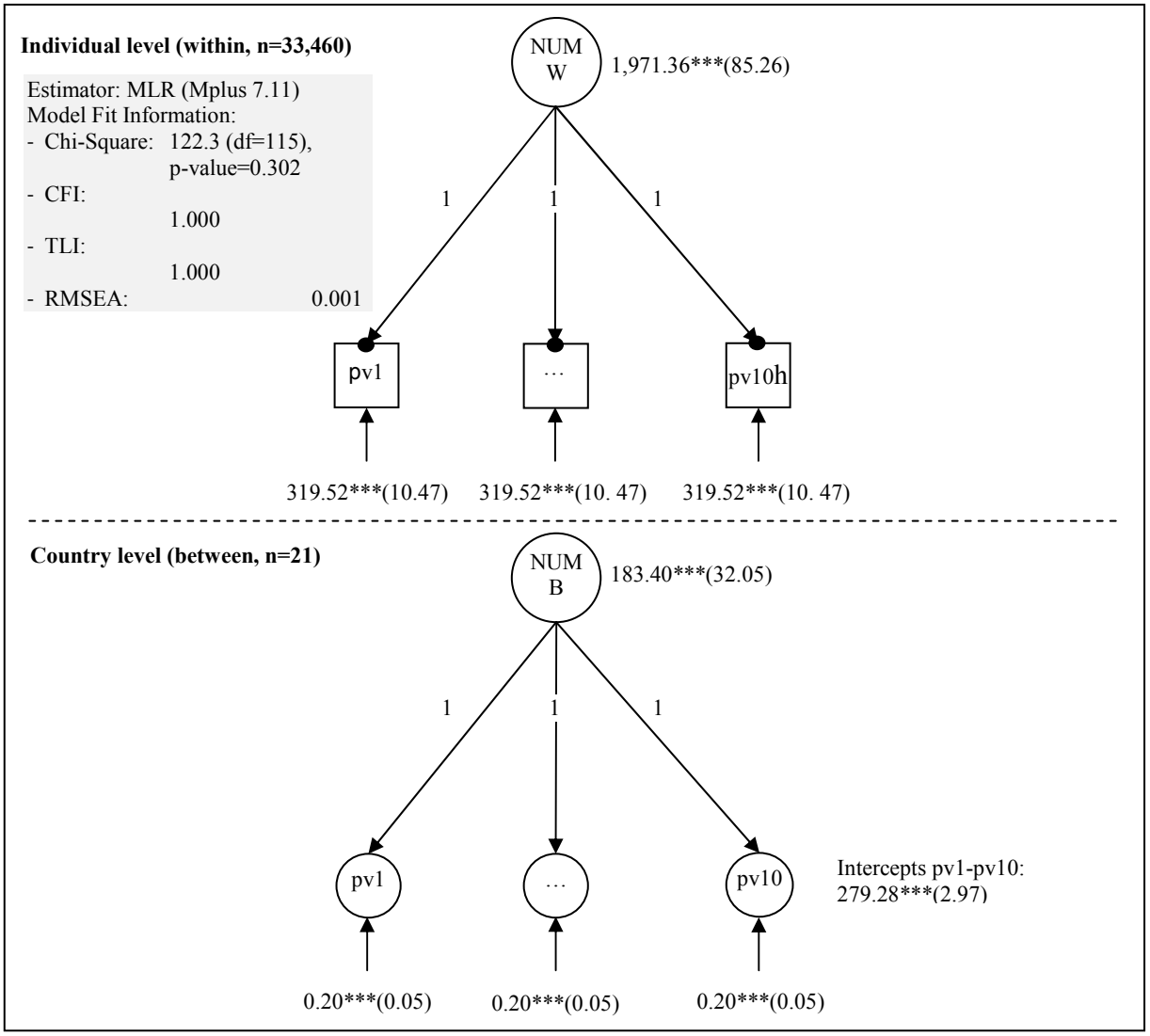
Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria; pared: parental education low (ISCED 0-2), high (ISCED 56); estimates are obtained from separate country models that take into account complex sampling structures, using the R package "survey" (Lumley, 2016) and plausible values for numeracy using the R package "svyPVpack" (Reif & Peterbauer, 2014).. *HE credential transmission*: marginal predicted probability of attaining higher education (ISCED 56) for adults whose parents have attained higher education minus the probability for those whose parents have attained compulsory education only (ISCED 0-2). *Numeracy skill transmission*: coefficient of higher educated parents (vs. parents with compulsory education, y-standardized). *ISEI ON HE credential*: coefficient of higher education attainment (vs. compulsory education, y-standardized). *ISEI ON Numeracy skill*: coefficient of numeracy skill (standardized). All models control for age (ref.: 40 year olds), female (ref.: male), foreign born parents (ref: natives) and currently out of employment (ref.: employed). Standard errors in brackets.

Appendix B: Two-level CFA measurement model of numeracy proficiency

Instead of observed proficiency scores, the PIAAC design of the cognitive assessment provides ten plausible values (PVs) which are imputed from a posteriori distribution that scales the cognitive test items using a latent regression item response model that is supplemented by socio-demographic background information. To keep individuals response burden low and to achieve broad cognitive skills coverage at the same time, the full set of cognitive items is distributed across linked assessment booklets. Each survey respondent receives only one booklet, and the responses are then aggregated to maintain a wide range of content representation. This allows for an efficient estimation of reliable population characteristics. The PIAAC methodology accounts for uncertainty associated with the multiple imputed PVs (see more on the methodology in OECD, 2013c, Chapter 17: Scaling Cognitive Data). This implies that our estimation procedure must account for the imputation variance in addition to the sampling error component. To account for the uncertainty associated with this multiple imputation technique in the two-level analysis, individual skills are modelled as a latent construct using all ten PVs within a Confirmatory Factor Analysis (CFA) framework (Brown 2006). Since each one of the ten PVs is equally likely representing the unobserved true proficiency score, they are constrained to load equally on the latent factor, having the same error variances, as well as the same intercepts at the country level.

Figure B1 is a graphical representation of the two-level CFA measurement model that mimics the latent regression model used in the PV methodology, including the estimated results for numeracy. Note that each of the ten plausible values of the numeracy score is constraint to load equally on the unobserved latent skills variable, have equal errors and intercepts. The model fit based on CFI/TLI, RMSEA and SRMR is excellent. The model is even acceptable according to the chi-square test, which is sensitive to large sample sizes, and thus it is safe to conclude that the differences between the estimated (co-)variance matrix and the empirical one are negligible.

Figure B.1: Measurement of the latent variable numeracy (two-level CFA model)



Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria; *** p<.001, ** p<.01, * p<.05, ° p<.1.
Factor loadings and residual variances are constraint to be equal on each level, as well as the intercepts of the indicator variables.

Supplement

Table S1: Contextual moderation effects of country level variables (models omitting vocational specificity)

	K1: HE cred. ON PE	K2: Num. ON PE	K3: Lit. ON PE
Random slope ON			
Age of first selection	-0.047 (0.034)	0.027 (0.564)	0.083 (0.545)
Bargaining coordination	-0.165*** (0.047)	-2.839*** (0.754)	-2.289** (0.786)
Expenditure on educ. (%GDP)	-0.074 (0.089)	0.359 (1.741)	0.644 (1.941)
Mean IV: PE, HE, Num, Lit	-0.136* (0.068)	0.264 (1.426)	-0.428 (1.489)
Intercepts			
Random slope	3.744*** (0.557)	38.301*** (10.092)	31.874** (9.867)
Dependent variable	4.212*** (0.546)	283.225*** (16.913)	275.755*** (16.894)
Residual variance			
Random slope	0.061*** (0.017)	16.030*** (4.115)	16.655** (5.557)
Dependent variable	0.087** (0.033)	65.403*** (16.497)	70.549*** (15.911)
Residual correlation	-0.022 (0.020)	-14.941° (8.650)	-22.219*** (6.178)
	K4: ISEI ON Cred.	**K5: ISEI ON Num.**	**K6: ISEI ON Lit.**
Random slope ON			
Age of first selection	-0.571 (0.458)	-0.187 (0.116)	-0.232° (0.123)
Bargaining coordination	-0.270 (0.498)	0.480*** (0.130)	0.475** (0.156)
Expenditure on educ. (%GDP)	-0.861 (1.006)	0.822* (0.373)	0.969** (0.334)
Mean IV: PE, HE, Num, Lit	-0.111 (0.788)	-0.588** (0.186)	-0.576** (0.186)
Intercepts			
Random Slope	37.444*** (7.209)	1.597 (1.656)	1.095 (1.935)
Dependent Variable	31.914*** (5.963)	34.944*** (4.729)	34.096*** (4.203)
Residual variance			
Random slope	6.685** (2.543)	0.525° (0.272)	0.649* (0.272)
Dependent variable	5.609** (1.829)	4.202* (1.881)	4.216* (1.910)
Residual correlation	-2.590 (1.629)	1.333° (0.716)	1.261° (0.732)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.

Table S2: Contextual moderation effects of country level variables (models omitting age of first selection)

	K1: HE cred. ON PE	K2: Num. ON PE	K3: Lit. ON PE
Random slope ON			
Vocational specificity	0.010** (0.003)	0.109* (0.049)	0.099* (0.048)
Bargaining coordination	-0.169** (0.056)	-3.107***(0.767)	-2.570** (0.796)
Expenditure on educ. (%GDP)	-0.102* (0.045)	0.552 (1.103)	0.941 (1.330)
Mean IV: PE, HE, Num, Lit	-0.147** (0.054)	0.185 (1.188)	-0.425 (1.311)
Intercepts			
Random slope	3.138***(0.341)	36.946***(6.814)	30.836***(8.351)
Dependent variable	2.529***(0.331)	273.010***(10.443)	282.978***(12.152)
Residual variance			
Random slope	0.044* (0.021)	12.506** (3.857)	13.496** (4.800)
Dependent variable	0.104* (0.044)	63.249***(16.296)	68.710***(15.806)
Residual correlation	-0.010 (0.032)	-18.005* (8.337)	-18.421** (5.975)
	K4: ISEI ON Cred.	**K5: ISEI ON Num.**	**K6: ISEI ON Lit.**
Random slope ON			
Vocational specificity	0.113** (0.040)	0.035***(0.010)	0.038** (0.012)
Bargaining coordination	-0.314 (0.467)	0.529***(0.148)	0.553** (0.183)
Expenditure on educ. (%GDP)	-1.320 (0.813)	0.695** (0.203)	0.790***(0.192)
Mean IV: PE, HE, Num, Lit	-0.107 (0.666)	-0.709***(0.156)	-0.715***(0.174)
Intercepts			
Random Slope	30.850***(4.751)	-0.866 (1.506)	-1.808 (1.412)
Dependent Variable	27.477***(4.579)	29.179***(5.158)	27.533***(4.937)
Residual variance			
Random slope	4.918* (2.030)	0.390* (0.165)	0.516** (0.169)
Dependent variable	5.923** (1.953)	4.354***(1.247)	4.490** (1.315)
Residual correlation	-2.390° (1.221)	1.224** (0.423)	1.199** (0.420)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.

Table S3: Contextual moderation effects of country level variables (models including a countries' share of large firms)

	K1: HE cred. ON PE	K2: Num. ON PE	K3: Lit. ON PE
Random slope ON			
Vocational specificity	0.012** (0.004)	0.180** (0.056)	0.170** (0.057)
Bargaining coordination	-0.133** (0.050)	-2.359***(0.670)	-1.838* (0.745)
Expenditure on educ. (%GDP)	-0.156** (0.052)	-1.566 (1.166)	-1.153 (1.368)
Mean IV: PE, HE, Num, Lit	-0.207***(0.053)	-1.039 (0.814)	-1.652° (0.948)
Share of large firms	0.140° (0.077)	2.485** (0.722)	2.597** (0.858)
Intercepts			
Random slope	-0.018 (0.022)	274.718***(14.503)	281.836***(18.266)
Dependent variable	2.595***(0.357)	274.718***(14.503)	281.836***(18.266)
Residual variance			
Random slope	0.088° (0.045)	0.193***(0.053)	0.138** (0.046)
Dependent variable	2.747** (0.903)	5.617* (2.820)	6.596 (4.514)
Residual correlation	0.014 (0.091)	0.033 (1.962)	0.608 (1.689)
	K4: ISEI ON Cred.	**K5: ISEI ON Num.**	**K6: ISEI ON Lit.**
Random slope ON			
Vocational specificity	0.113** (0.040)	0.033** (0.012)	0.033** (0.012)
Bargaining coordination	-0.227 (0.518)	0.552***(0.145)	0.583** (0.177)
Expenditure on educ. (%GDP)	-1.469 (0.949)	0.578 (0.357)	0.671* (0.307)
Mean IV: PE, HE, Num, Lit	-0.244 (0.688)	-0.680***(0.156)	-0.690***(0.156)
Share of large firms	0.341 (0.535)	0.244 (0.269)	0.348 (0.233)
Intercepts			
Random Slope	-2.581* (1.053)	32.754***(4.763)	31.836***(4.613)
Dependent Variable	30.684***(7.396)	1.075** (0.385)	0.999* (0.404)
Residual variance			
Random slope	5.105** (1.695)	3.818** (1.317)	3.942** (1.399)
Dependent variable	29.944***(5.989)	-0.689 (1.395)	-1.310 (1.575)
Residual correlation	0.828 (0.728)	0.599 (0.590)	0.473 (0.582)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.

Table S4: Contextual moderation effects of country level variables (models including a countries' share of females among the workforce)

	K1: HE cred. ON PE		K2: Num. ON PE		K3: Lit. ON PE	
Random slope ON						
Vocational specificity	0.010°	(0.006)	0.181*	(0.084)	0.133°	(0.075)
Bargaining coordination	-0.177**	(0.059)	-2.759**	(0.870)	-2.746**	(0.944)
Expenditure on educ. (%GDP)	-0.108	(0.075)	-0.516	(1.443)	-0.077	(1.506)
Mean IV: PE, HE, Num, Lit	-0.153**	(0.056)	-0.146	(1.102)	-0.692	(1.147)
Share of females	-0.693	(1.881)	5.972	(28.682)	-27.154	(28.278)
Intercepts						
Random slope	-0.014	(0.025)	337.476***	(35.909)	296.225***	(46.379)
Dependent variable	3.501**	(1.278)	337.476***	(35.909)	296.225***	(46.379)
Residual variance						
Random slope	0.086*	(0.039)	0.192***	(0.053)	0.139**	(0.046)
Dependent variable	0.798	(1.958)	11.294**	(3.442)	12.073**	(4.219)
Residual correlation	-3.809	(2.424)	-94.310°	(48.968)	-19.477	(60.125)
	K4: ISEI ON Cred.		**K5: ISEI ON Num.**		**K6: ISEI ON Lit.**	
Random slope ON						
Vocational specificity	0.085°	(0.044)	0.028*	(0.013)	0.025°	(0.015)
Bargaining coordination	-0.723	(0.637)	0.434**	(0.165)	0.388°	(0.231)
Expenditure on educ. (%GDP)	-1.338°	(0.736)	0.722*	(0.306)	0.857**	(0.283)
Mean IV: PE, HE, Num, Lit	-0.164	(0.733)	-0.695***	(0.151)	-0.648***	(0.176)
Share of females	-26.172	(21.575)	-5.038	(4.560)	-6.926	(6.954)
Intercepts						
Random Slope	-2.732*	(1.103)	53.114***	(12.780)	53.686***	(12.062)
Dependent Variable	43.376**	(13.691)	1.049*	(0.468)	0.942°	(0.516)
Residual variance						
Random slope	5.340**	(1.745)	3.314*	(1.452)	3.279*	(1.413)
Dependent variable	48.020**	(14.660)	2.797	(3.610)	3.677	(5.557)
Residual correlation	-16.154	(18.676)	-29.868*	(14.706)	-31.21*	(13.814)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.

Table S5: Contextual moderation effects of country level variables (models omitting country data of CA. EE, FI)

	K1: HE cred. ON PE	K2: Num. ON PE	K3: Lit. ON PE
Random slope ON			
Vocational specificity	0.014** (0.005)	0.122° (0.072)	0.125° (0.074)
Bargaining coordination	-0.152* (0.069)	-3.899*** (0.727)	-3.220*** (0.800)
Expenditure on educ. (%GDP)	-0.090 (0.091)	-0.475 (1.547)	-0.195 (1.809)
Mean IV: PE, HE, Num, Lit	-0.171** (0.065)	1.015 (1.145)	0.281 (1.243)
Intercepts			
Random slope	2.169*** (0.374)	35.182*** (6.689)	28.729*** (7.002)
Dependent variable	0.766*** (0.197)	279.207*** (18.899)	301.548*** (17.732)
Residual variance			
Random slope	0.048 (0.032)	10.098* (4.402)	9.984* (4.360)
Dependent variable	0.117** (0.042)	66.129*** (17.322)	62.798** (18.204)
Residual correlation	-0.054 (0.036)	-18.512* (7.756)	-22.527*** (5.843)
	K4: ISEI ON Cred.	**K5: ISEI ON Num.**	**K6: ISEI ON Lit.**
Random slope ON			
Vocational specificity	0.099* (0.046)	0.039* (0.016)	0.039* (0.016)
Bargaining coordination	-0.650 (0.628)	0.616** (0.209)	0.680** (0.253)
Expenditure on educ. (%GDP)	-0.975 (1.039)	0.786* (0.306)	0.851** (0.295)
Mean IV: PE, HE, Num, Lit	-0.546 (0.986)	-0.867*** (0.152)	-0.869*** (0.179)
Intercepts			
Random Slope	35.463*** (5.144)	-1.551 (1.206)	-2.068 (1.527)
Dependent Variable	30.330*** (6.770)	31.075*** (5.329)	29.443*** (4.957)
Residual variance			
Random slope	5.629** (1.842)	0.379° (0.198)	0.565** (0.207)
Dependent variable	5.012** (1.488)	4.588** (1.664)	4.544** (1.699)
Residual correlation	-2.156° (1.146)	1.317* (0.605)	1.188* (0.582)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.

Table S6: Contextual moderation effects of country level variables (30-39 year olds)

	K1: HE cred. ON PE	K2: Num. ON PE	K3: Lit. ON PE
Random slope ON			
Vocational specificity	0.009 (0.006)	0.221** (0.082)	0.221* (0.090)
Bargaining coordination	-0.168***(0.046)	-2.987***(0.793)	-2.770***(0.757)
Expenditure on educ. (%GDP)	-0.109 (0.080)	-0.275 (1.332)	0.169 (1.683)
Mean IV: PE, HE, Num, Lit	-0.116* (0.051)	-0.136 (1.173)	-0.589 (1.271)
Intercepts			
Random slope	2.894***(0.620)	24.756** (7.453)	22.809* (8.894)
Dependent variable	4.505***(0.836)	261.503***(13.969)	265.833***(18.492)
Residual variance			
Random slope	0.009 (0.028)	4.458 (6.252)	8.306 (5.554)
Dependent variable	0.076* (0.033)	46.859***(13.197)	68.391***(14.509)
Residual correlation	-0.009 (0.026)	-13.336 (8.151)	-21.189** (7.613)
	K4: ISEI ON Cred.	**K5: ISEI ON Num.**	**K6: ISEI ON Lit.**
Random slope ON			
Vocational specificity	0.133* (0.058)	0.010 (0.012)	0.030** (0.009)
Bargaining coordination	-0.355 (0.609)	0.341* (0.148)	0.348* (0.145)
Expenditure on educ. (%GDP)	-1.021 (1.069)	1.034***(0.292)	1.028***(0.218)
Mean IV: PE, HE, Num, Lit	-0.140 (0.916)	-0.983***(0.196)	-0.929***(0.177)
Intercepts			
Random Slope	32.158***(6.988)	0.134 (1.284)	0.030 (1.292)
Dependent Variable	26.918** (8.419)	31.351***(4.332)	34.609***(4.402)
Residual variance			
Random slope	6.636* (3.238)	0.169 (0.183)	0.250 (0.228)
Dependent variable	4.490** (1.520)	4.139** (1.450)	3.839** (1.461)
Residual correlation	-2.841* (1.368)	0.761** (0.270)	0.977** (0.299)

Estimates are obtained using the Robust Maximum Likelihood estimator implemented Mplus (Muthén and Muthén 2014). Skill proficiency is modelled as a latent variable using ten plausible values in numeracy and literacy, respectively (for details see Appendix B). Cred.: Credential, PE: parental education, Num.: Numeracy, Lit.: Literacy, ISEI: ISEI score of occupational status.

Source: OECD PIAAC 2011/12, GESIS 2014, Statistik Austria, Eurostat, OECD, Visser (2013); *** p<.001, ** p<.01, * p<.05, ° p<.1.